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US 3627903A
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(54) **Ribbon cable**

(57) In multi-core electric cable in which the cores extend in side-by-side spaced and parallel relationship, instead of producing the cable with the cores continuously interconnected by surrounding insulation so that when cut into lengths the insulation has to be pulled or cut apart in order to separate the cores for connecting, the cable is made at the outset with regions 35 at intervals along its length where the cores have never been interconnected. Methods of manufacturing the cable include those in which each core has an individual insulating sheath 34 interconnected to form the multi-core cable by the bonding of the sheaths together or to backing strip material or to both. In application to multi-core cables made from bare conductors sandwiched between strips of insulating material separation of the cores at intervals is achieved either by omitting at intervals the bonding of the insulating material or by omitting the insulating material at intervals or by a combination of both. Apparatus for, and methods of, so manufacturing flat multi-core electric cable are described.

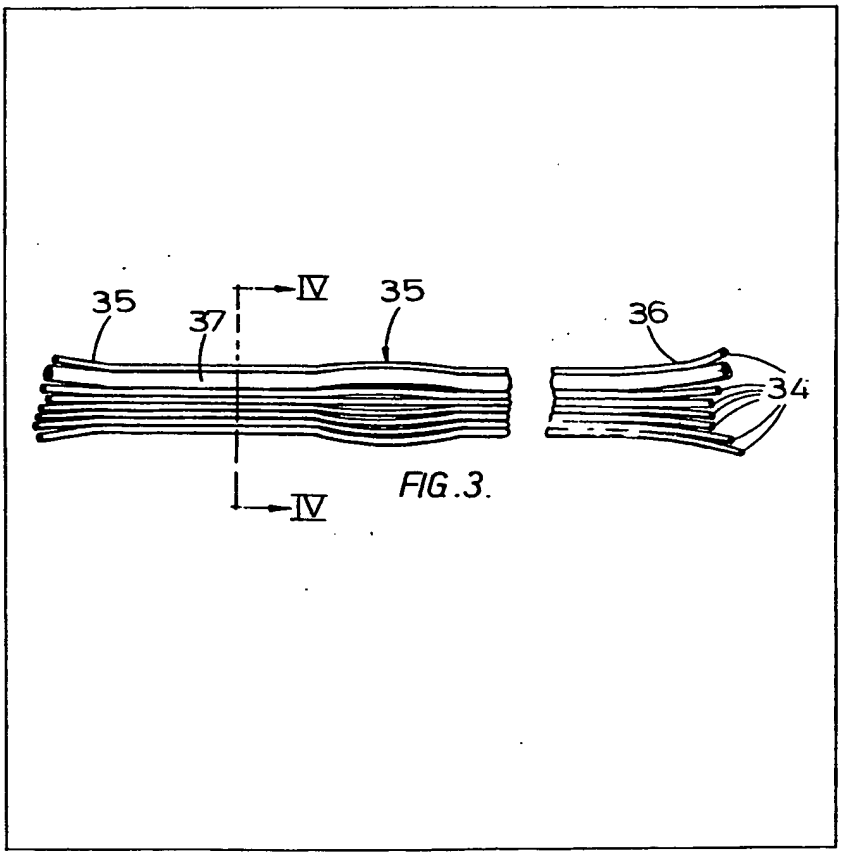

FIG.3.

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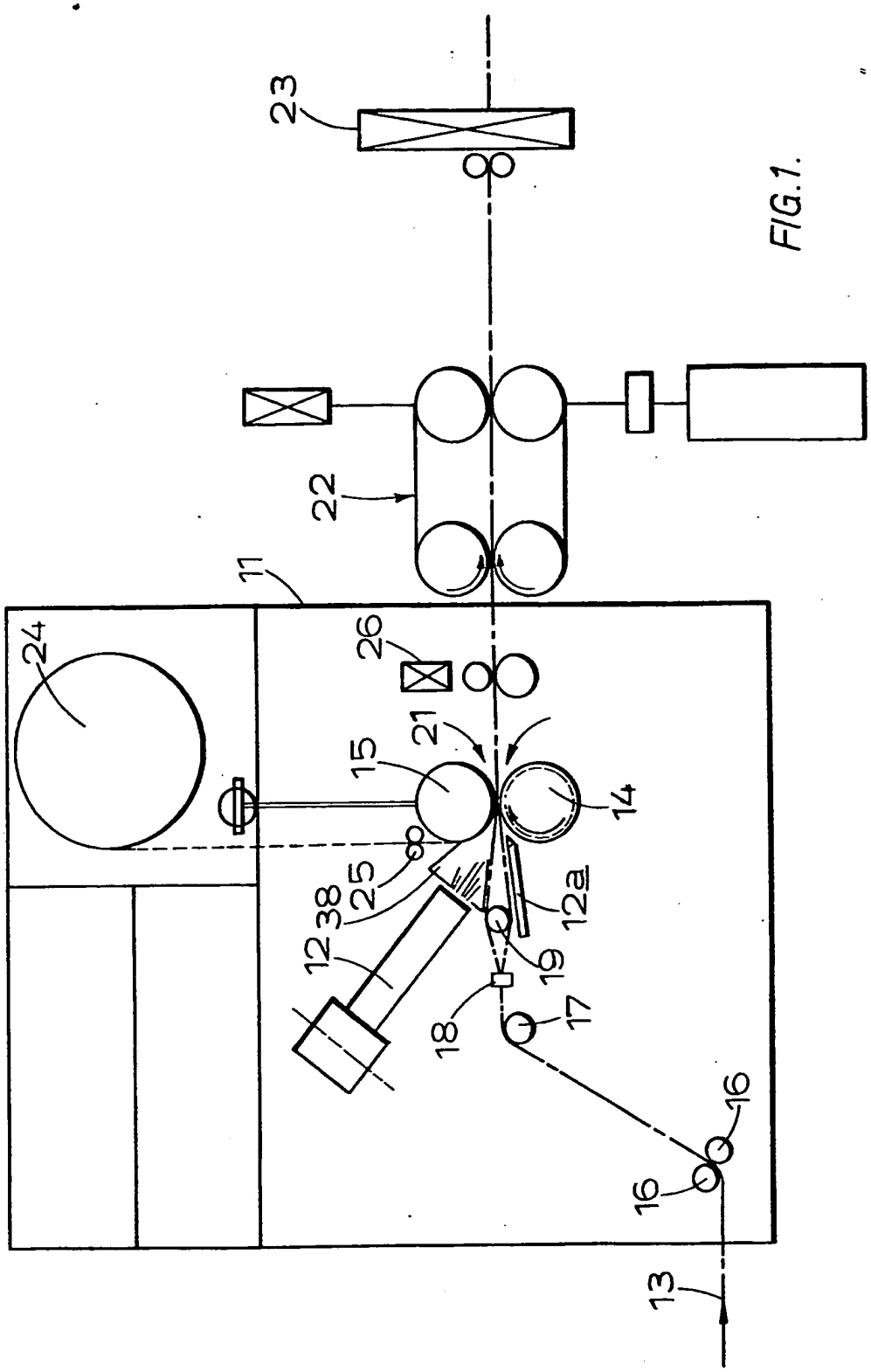

FIG.1.

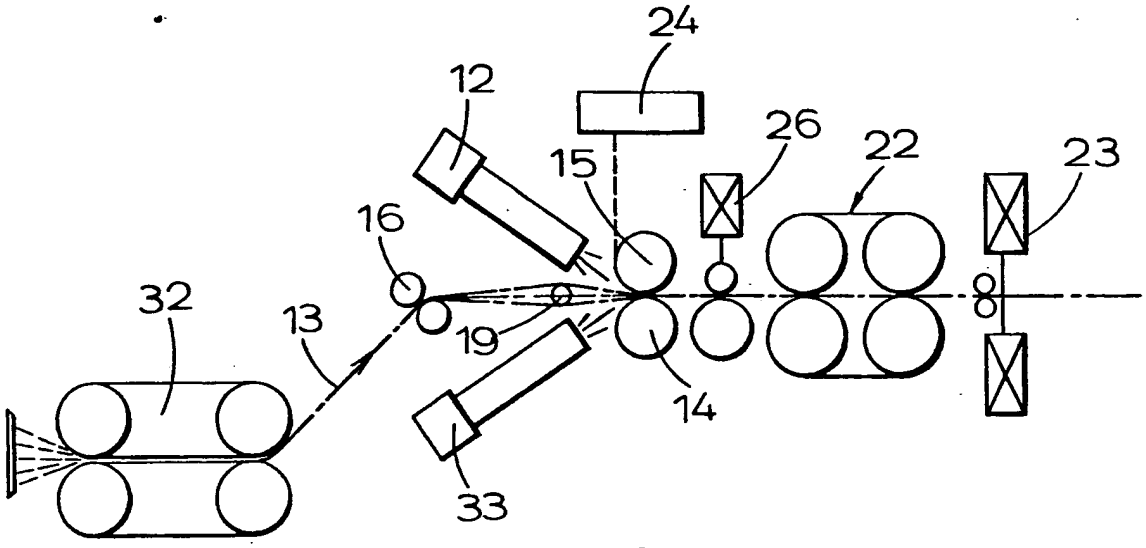

FIG.2.

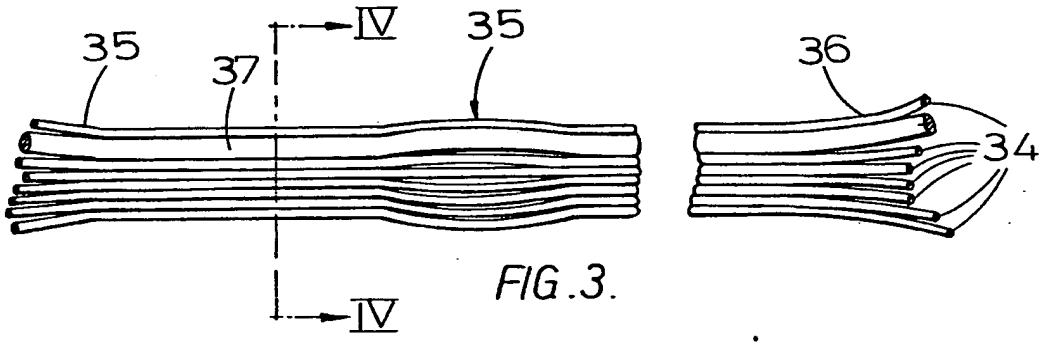

FIG.3.

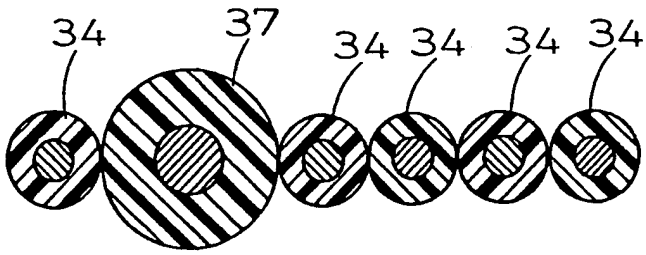

FIG.4.

SPECIFICATION

Ribbon cable

This invention relates to multi-core electric cables wherein the cores extend in side-by-side, spaced and generally parallel relationship, and to a method of and apparatus for, manufacturing such cables.

The term multi-core cable is used herein to include such cable forms as a flat cable where the spaced parallel cores have a common insulting sheath, and ribbon cable, by which term is meant a flat cable comprising a plurality of leads each having a conductive core in an electrically insulating sheath, the leads being positioned parallel and side-by-side, and the leads being secured together to constitute the cable by having their insulating sheaths interconnected.

There are known forms of ribbon cable wherein the sheaths of the leads are interconnected along their lengths by being formed integral with one another, having been formed simultaneously around their respective cores. There are other known forms where the sheaths are interconnected along their length by an adhesive which secures each sheath to its neighbour. There are still other known forms of ribbon cable as shown in United States patent number 3 226 278 wherein the sheaths are formed from thermoplastic material and are interconnected by fusion of each sheath to its neightbour along its length. In each case the ribbon cable is manufactured as a continuous length which is either cut to predetermined lengths and stored ready for use, or is stored as a continuous length on a reel, and when required a predetermined length of cable is cut from the reel. In order to use the predetermined length of ribbon cable the end regions of the leads thereof must be separated from one another, and if necessary the extremities are stripped of insulation to facilitate making of an electrical connection thereto.

There is also known a form of flat cable wherein a plurality of flat tape-like cores extend in spaced side-by-side parallel relationship and are insulated and held in position relative to one another by upper and lower insulating layers which are interconnected around and between the cores throughout their length by adhesive.

A problem found with flat cable and ribbon cable is the separation of the cores at the end regions of the predetermied lengths of cable. The usual method of separating the leads of ribbon cable is to pull the leads apart, and this is usually a manual, and therefore expensive operation. Moreover the operation entails a high failure rate as a result of one or more of the sheaths of the leads tearing as it is separated from its neighbour. Ideally of course, machines will separate along their common boundary or along the adhesive boundary in the case of adhesively interconnected leads. However it is frequently found that the bond between the sheaths of the leads is too strong to permit separation by pulling the sheaths apart, and tearing of the sheaths of one or more of the leads is the result. Such tearing exposes the conductive core at a region where it should be insulated by its sheath, and often the resultant length of ribbon cable is unusable, particularly if it has been cut originally to the exact required length. In relation to the aforementioned flat cable the insulating layers are usually cut or scraped away to expose the cores, again a manual and thus expensive operation not without risk of damaging the cores.

It is an object of the present invention to provide a method of manufacturing multi-core cable wherein the disadvantages mentioned above are minimised, and also to provide apparatus for manufacturing such cable.

It is an important object of the invention to produce multi-core cable at the outset with regions at which individual conductors are separate, having never been interconnected.

The present invention consists in a method of manufacturing multi-core cable of the kind in which a plurality of conductive cores are held in parallel and side-by-side relation by surrounding insulation, the method including the steps of arranging individual separate cores in such relation and while so retained interconnecting the cores by the insulation of the cable characterised in that the interconnecting of the cores is interrupted at intervals along the length of the cable to produce regions at which the cores are separate.

Interruption of the interconnecting of the cores may be omitted for the regions in which the cores are to be separate, bonding of the insulation of the multi-core cable or omitting insulation to be bonded or by omitting both the bonding at at least some of the insulation to be bonded.

The invention is applicable to all the previously known methods of producing continuously interconnected multi-core cables. Thus each conductive core may have its own insulating sheath and be held in place by bonding the sheaths one to another or to at least one backing strip of insulating material or both to one another and to one or more insulating backing strips, except at the said regions. Alternatively the conductive cores may be bare and be insulated and held in their relative positions by being sandwiched between opposed, for example upper and lower, insulating strips which are bonded one to the other except at the regions. Bonding may be by adhesive or ultrasonic or high-frequency fusion.

Alternatively backing strip for conductive cores each having its own insulating sheath may be supplied in lengths corresponding to the fully interconnected lengths of cable and arranged with gaps between successive lengths corresponding to the said regions so that in these regions there is no tape to be bonded to the sheaths. Again, where there is more than one backing strip, one or both backing strips is divided into such successive lengths and on at least one side of the multi-core cable there is no tape to be bonded to the sheaths. Similarly in methods of production in which bare conductors are sandwiched between a pair of insulating strips applied to opposite sides of the array of conductors and then the strips bonded one to another, one or both the insulating strips may be provided in lengths corresponding to the fully interconnected lengths of cable and arranged with gaps between successive

lengths corresponding to the said regions so that in these regions the conductors are separate and on at least one side of the multi-core cable are bare and exposed.

One example of the invention is illustrated in the accompanying drawings, wherein:-

Figure 1 is a diagrammatic representation of apparatus for producing ribbon cable;

Figure 2 is a view similar to Figure 1 of an alternative apparatus;

Figure 3 is a plan view of a length of ribbon cable; and

Figure 4 is a sectional view on line IV-IV of Figure 3, to an enlarged scale, of a length of ribbon cable.

Referring first to Figure 1 of the drawings, the apparatus comprises a bonding module 11 incorporating a hot air blower 12, a drive mechanism for driving leads through the apparatus, and a programmable control mechanism for controlling operation of the drive, the heater 12 and certain additional elements of the apparatus as will be described more fully hereinafter.

A plurality of conductive leads each comprising a conductive core within a thermoplastic synthetic resin, preferably p.v.c., sheath are drawn from respective storage reels (not shown) and follow the path of the broken line 13 through the apparatus.

The module 11 carries a profile roller 14 which is driven by an electric motor. The roller 14 is formed from aluminium and its cylindrical surface is formed with a plurality of circumferentially extending part circular grooves capable of receiving the leads to be formed into the ribbon cable. Positioned adjacent the roller 14 is a pressure roller 15 the outer surface of which is resilient. The pressure roller 15 is adjustable in position towards and away from the roller 14 and can rotate about an axis parallel to the rotational axis of the roller 14. Leads passing between the rollers 14, 15 are gripped therebetween, and upon clockwise rotation of the roller 14 the leads are drawn through the apparatus. Thus the leads initially pass between a pair of tensioning rollers 16 which ensure that the length of the leads between the rollers 16 and the rollers 14, 15 are maintained at a predetermined tension. After the rollers 16 the leads pass over a guide pulley 17 and through a guide block 18. The guide block 18 ensures that the leads are positioned side-by-side, and between the guide block 18 and the rollers 14, 15 is a cylindrical post 19. Alternate leads pass to one side of the post 19, while the remaining leads pass to the other side of the posts 19. Thus intermediate the post 19 and the roller 14, 15 the leads are separated from one another. The heater 12 is in the form of a hot air blower which directs heated air onto the separated leads between the posts 19 and the rollers 14, 15. The separating action effected by the post 19 ensures that the leads do not mask each other from the flow of hot air.

The fan which drives air through the blower 12, and the heater elements which heat the air are both controlled to ensure that the thermoplastic sheaths of the leads are raised to an appropriate temperature immediately before passing between the rollers 14, 15 such that as the leads pass between the rollers 14, 15 the pressure applied to the leads by the rollers causes the heated thermoplastic sheath of each lead to touch and fuse to the heated thermoplastic sheath of its neighbour. A pair of nozzles 21 direct cold air onto the leads as they pass out from between the rollers 14, 15 and the effect of the cold air is to cool the now fused sheaths of the leads, and also to cool the rollers 14, 15. Thereafter the formed ribbon cable, wherein the leads are positioned side-by-side and parallel, with each thermoplastic sheath fused to its neighbour, is received by a twin conveyor system 22. The conveyor system 22 passes the ribbon cable to a guillotine mechanism 23 which is operated by the control mechanism of the module 11 to cut the ribbon cable into predetermined lengths.

The apparatus described so far will operate to produce ribbon cable wherein the sheaths of the leads are fused each to its neighbour throughout the whole length of the ribbon cable. However, it is desired to produce ribbon cable wherein there is no interconnection between the sheaths in regions predeterminedly spaced along the length of the cable. Thus the control mechanism contained in the module 11 causes interruption of the fusion process at predetermined intervals, the intervals being determined by the passage of time, or more preferably by the passage between the rollers 14, 15 of a predetermined length of the leads. The hot air blower 12 is movable from the operative position wherein it heats the sheaths of the leads to an inoperative position wherein the hot air directed from the blower 12 is received by an extractor duct 38. The direction of movement of the heater is not of importance but in the arrangement shown the heater will be moved laterally with respect to the length of the cable and parallel to the plane of the cable. It is to be recognised that the heater 12 could be moved in other directions to cause it to discharge its air into a suitably positioned duct 38 rather than onto the leads. The movement of the hot air blower 12 from its operative position to its rest position and back to its operative position is controlled by the control mechanism within the module 11. Thus after a predetermined length of ribbon cable has been produced the hot air blower 12 will be moved to its rest position while the rollers 14, 15 will continue to rotate, driving the leads through the apparatus. After a predetermined length of the leads has passed between the rollers, the hot air blower 12 will be returned to its operative position and the cable produced by the apparatus will thus include regions wherein the leads, although still extending side-by-side and parallel to one another, are not interconnected.

As mentioned above the guillotine 23 is also controlled by the control mechanism of the module 11 and its operation is so controlled that the ribbon cable is severed at or adjacent the mid-point of the regions of the cable wherein the leads are not interconnected. Thus the guillotine produces from the ribbon cable a plurality of predetermined lengths of ribbon cable each having end regions wherein the leads are not interconnected.

In order to increase the efficiency of the hot air blower 12 a reflector plate 12*a* is positioned beneath

the leads between the posts 19 and the rollers 14, 15, so ensuring that the under surfaces of the sheaths of the leads, in relation to the blower 12 are also heated.

It will be recognised that the form of ribbon cable produced by the apparatus described above has the leads interconnected by fusion of the sheaths of the leads each to its neighbour. However, if desired, the module 11 can include a tape feed mechanism 24 whereby a continous strip of thermoplastic tape is fed between the rollers 14, 15, simultaneously with the conductive leads. The tape passes from the mechanism 24 between tensioning rollers 25 and passes beneath the roller 15. It will be recognised therefore that one surface of the tape will be heated simultaneously with the heating of the sheaths of the leads. Thereafter, as the leads and the tape pass together between the rollers 14, 15 the sheaths of the lead will be fused each to the tape as well as each to its neighbour. Similarly of course although the tape will continue along the whole length of the ribbon cable in those regions of the cable wherein the sheaths of the leads are not interconnected they will not be fused to the tape either. The guillotine of course will cut through both the tape and the leads.

In a modification the grooves in the roller 14 are arranged to hold the leads separate from one another so that the leads fuse only to the backing strip defined by the tape. Once again when the heater 12 is moved to its rest position, a length of ribbon cable will be produced wherein the leads are not fused to the backing strip. Again therefore after the ribbon cable has been guillotined the cut lengths of ribbon cable will have end regions wherein the leads are separate from one another.

In a further modification an additional tape feed mechanism similar to the tape feed mechanism 24 and tensioning rollers similar to the tensioning rollers 25 may be provided below the level at which the leads are fed between the rollers 14, 15 and feed a continuous lower strip of thermoplastic tape between the rollers 14, 15 to engage the underside of the conductive leads. If necessary the reflector plate 12a may be re-positioned to direct hot air onto the surface of the underside tape which will engage the under surfaces of the sheaths of the leads. When the leads and the upper and lower tapes pass together between the rollers 14, 15, the leads are sandwiched between the tapes and the sheaths of the leads will be fused to both the tapes as well as each to its neighbour. As in the previous examples when the heater 12 is moved to its rest position, a length of ribbon cable will be produced wherein the leads are not fused to the tapes nor to one another and again, after the ribbon cable has been guillotined, the cut lengths of ribbon cable will have end regions wherein the leads are separate from one another.

It will be recognised that the control mechanism of the module 11 can be set to produce a wide range of different predetermined spacings between the regions of the cable wherein the leads remain separate from one another.

Moreover if desired the guillotine could be rendered inoperative, and the ribbon cable produced by the apparatus could be stored on a reel, the predetermined lengths then being severed when required.

Where thermoplastic tape on one or both sides of the leads is being used as either the sole means of securing the leads together to form the ribbon cable or alternatively as an adjunct to fusing the sheaths each to its neighbour, two lengths of ribbon cable can be produced simultaneously. The appropriate sets of leads are fed through the apparatus as described above, and a single backing strip on one or each side of the leads, in the form of thermoplastic tape sufficiently wide to lie across both sets of leads is fed from the mechanism 24. After the bonding process a slitting mechanism 26 positioned between the rollers 14, 15 and the conveyor mechanism 22 is operated to continuously slit the tape between the two sets of leads so that two separate ribbon cables pass through the conveyor mechanism 22 to the guillotine 23.

In the alternative apparatus shown in Figure 2 components common to the apparatus shown in Figure 1 carry the same reference numerals. The leads are drawn through the apparatus not by the driving action of the rollers 14, 15 but by the combined action of the twin conveyor unit 22 and a further twin conveyor unit 32 at the inlet of the apparatus. The conveyor unit 22 is driven at a speed in excess of the conveyor unit 32 to ensure that between the conveyors the leads are maintained in tension. In place of the reflector 12*a* the apparatus includes a second hot air blower 33 which directs hot air at the undersurfaces of the sheaths of the leads. The second hot air blower 33 is of course moved by the control mechanism in unison with the hot air blower 12 so that in the rest position of both heaters their hot air is received by an extractor duct like the duct 38 in Figure 1.

As with the apparatus described with reference to Figure 1 thermoplastic tape can, if desired be fed between the rollers 14, 15 from a tape feed mechanism 24 on one or each side of the leads and again if desired the profiling of the roller 14 can be arranged so that the sheaths of the leads are fused only to the backing tape or tapes. Again, the or each tape can be sufficiently wide to accommodate two ribbon cables in which case the tape slitting mechanism 26 is utilised to separate the two ribbon cables before they pass into the conveyor mechanism 22.

An example of one form of the ribbon cable which can be produced by the apparatus of Figure 1 and Figure 2 is shown in Figure 3. In the ribbon cable of Figure 3 the individual leads 34 have their sheaths each fused to the neighbouring sheath to produce a flat ribbon cable wherein the leads extend parallel to one another and in side-by-side relationship. In Figure 3 there is shown a region 35 of the cable where the leads are not secured together and an end region 36 formed by severing the cable through a region 35. It will be recognised that as the cable is produced the leads within each region 35 will remain side-by-side and parallel though they are shown spaced in Figure 3 for the purposes of clarity. Figure 4 shows an enlarged cross-sectional view of a ribbon cable similar to that shown in Figure 3 and illustrates that it is not essential that all of the leads are of the

same diameter. Thus in Figure 4 an increased diameter lead 37 is incorporated in the cable with a plurality of smaller diameter leads 34. The axis of the increased diameter lead 37 may lie in the same plane as that of the smaller diameter leads 34, as shown in Figure 4 or the axis of the increased diameter lead 37 may be displaced to one side of the plane containing the axes of the leads 34 so that on one side of the multi-core cable all the sheaths lie at the same level. In the event that thermoplastic tape is utilised as an adjunct to fusing the sheaths of the leads each to its neighbour then of course the tape will be fused to each of the sheaths of the leads and will lie generally in a plane parallel to the central plane of the cable. Moreover where the thermoplastic tape constitutes the means of securing the leads together to form the cable then there will be a small spacing in the lateral dimension of the cable between the leads.

In the examples described above there are those where in addition to the leads having their sheaths bonded together, the sheaths are also bonded, on one or each side of the cable to a continuous length of backing strip in the form of a thermoplastic tape, and those wherein the sheaths are bonded only to the tape or tapes. At predetermined points there is in the one case no fusion between the sheaths of the leads and no fusion between the sheaths and the tape or tapes, and in the other case no fusion between the sheaths and the tape or tapes. In both cases in the severing operation the leads and the tape or tapes are severed simultaneously. However, in a modification, the apparatus, which is arranged to apply tape to one side only of the cable, includes a tape cutter in advance of the bonding module. The tape cutter is controlled by the control module and is operated to sever the tape entering the bonding module to produce lengths of tape equal in length to the distance between adjacent regions of the cable wherein the leads are separate from one another. The apparatus further includes a pause mechanism whereby the feed rollers 25 are stopped and the supply of tape to the bonding module is interrupted to correspond to the period of time when the heating process is interrupted. The tape cutter is disposed below the feed rollers 25 and when the feed rollers 25 are started again after the pause the leading end of the tape is fed down until, assisted by gravity, it makes contact with the leads below. The leads take the leading end of the tape forwards and rethread the tape between the rollers 14 and 15. Thus the cable issuing from the bonding module comprises, in the one case a plurality of leads having portions where their sheaths are fused together and fused to a length of backing strip spaced apart by regions wherein the sheaths are separate from one another, and there is no backing strip and in the other case having portions where the sheaths are bonded to a length of strip spaced apart by regions where there is no strip. In both cases the backing strip has been cut to the appropriate length, and has in effect been positioned by the apparatus so as to correspond only to the portions of the leads wherein the sheaths are interconnected. In the second case, where the sheaths are never bonded together the bonding module can if desired be in a continuously operating mode since the necessary bonding will be achieved by the spacing of the cut ends of consecutive lengths of backing strip. The fact that the sheaths of the leads will be heated in regions where they are not to be bonded to backing strip does not present any serious problems with most sheath materials but of course if desired the heating can be interrupted as described above.

In combination with cut lengths of tape on one side of the cable a continuous length of tape may be applied as a backing strip to the other side of the cable but as this second backing strip is not to be bonded to the leads in the regions where there is no strip on the one side of the cable, it is necessary that in this variant heating be interrupted so that the leads will not be bonded to the second backing strip in the regions in which the leads are required to be separate. Instead of the second backing strip being continuous it too may be in cut lengths corresponding in length and position to those on the one side of the cable. For this purpose a tape cutter as described above and under the control of the pause mechanism may be provided for the lower tape. Provided that the lower tape is sufficiently stiff for its leading end to be projected forward from its feed rollers until it engages the underside of the leads and be taken forward with the leads, the lower tape will be rethreaded between the rollers 14, 15 in a manner generally similar to the rethreading of the upper tape.

It will be recognised since predetermined lengths of ribbon cable can be produced having end regions wherein the leads are separate from one another then the problems found with the known forms of ribbon cable are obviated. Thus since the leads, at the end regions are separate from one another having never been interconnected, then the problems of the prior art in relation to the separation of the leads at the end regions of the length of cable is not found.

The foregoing description has been in relation to ribbon cable wherein the leads each include a conductive core within an individual sheath. However, with relatively minor modifications the apparatus can be used to produce a form of multi-core cable wherein a plurality of bare conductive cores are insulated, and held in position relative to one another by a common electrically insulating sheath. The bonding station receives a plurality of continuous cores in side-by-side parallel spaced relationship and receives above and below the cores respectively upper and lower insulating strips. The insulating strips are thermoplastic tapes generally similar to the thermoplastic tape described above in relation to the backing strip and may be similar in thickness to such backing strips or thicker or thinner. In the bonding station the hot air blower heats the mutually presented surfaces of the upper and lower strips and the rollers between which the cable passes press the upper and lower strips together so that they fuse together between and around the bare cores.

Again, the heating is interrupted at predetermined points along the length of the cable being produced so that the resultant cable has regions wherein the

upper and lower strips are fused together between and around the cores and so insulate and hold the cores in position relative to one another interspaced by regions of considerably smaller length in which the upper and lower strips are not interconnected.

Again, the cable is severed in the guillotine either at an end of or at the mid-point of the regions wherein the upper and lower strips are not interconnected, thus producing lengths of flat cable having one or both ends wherein the cores are readily accessible without cutting or scraping the upper and lower strips to expose the cores.

In a modification of the foregoing technique one or both strips can be cut prior to passing through the bonding station and the cut ends of consecutive lengths of the cut strip can be spaced by a pause mechanism so that in the resultant cable the regions where to cores are interconnected are defined by the absence of one or both strips. As with the similar technique mentioned earlier the heater can if desired remain operative or can be interrupted at said regions. Where both strips are cut and spaced then of course there is less need to interrupt the operation of the heater.

Although in the above-described apparatus hot air welding is used to join thermoplastics insulating materials, the insulating material may alternatively be bonded by the use of adhesive or by other known methods of joining synthetic resin materials for example by ultrasonic or high-frequency fusion.

The apparatus, instead of being arranged with the multi-core cable in a horizontal plane could be arranged to produce the multi-core cable in any other convenient orientation thereof. In such re-oriented apparatus opposed insulating strips or tapes on opposite sides of the cable would not then necessarily be upper and lower strips and it must be understood that these terms are used for convenience of description only and are not to be regarded as limitative.

In apparatus in accordance with the invention in which the leads are drawn through the apparatus not by the driving action of rollers (the rollers 14, 15 for example) but by other means such as the twin conveyor units 22 and 32 in Figure 2, it is not necessary for the rollers 14 and 15 to be driven, they may simply be allowed to rotate under the action of the moving leads. Furthermore in such apparatus used for manufacturing multi-core cable of the kind in which leads with individual insulating sheaths are joined side-by-side without the addition of a backing strip, provided that, as is again the case in the example of Figure 2, the leads are maintained in tension over the profile roller 14, the pressure roller 15 may be omitted. The tension on the leads and the profile of the roller 14 is sufficient to urge neighbouring sheaths into close contact to become bonded to one another. Omission of the roller 14 has the advantage of avoiding the distortion of the sheaths which is apt to result from pressure of the plain roller 14 on the sheaths softened by heating for bonding purposes.

CLAIMS

1. A method of manufacturing multi-core cable of the kind in which a plurality of conductive cores are held in parallel and side-by-side relation by surrounding insulation, the method including the steps of arranging individual separate cores in parallel and side-by-side relation, retaining the cores in such relation and, while so retained, interconnecting the cores by the insulation of the cable characterised in that the interconnecting of the cores is interrupted at intervals along the length of the cable to produce regions at which the cores are separate.

2. A method of manufacturing multi-core cable according to claim 1 comprising bonding the insulating sheaths of a plurality of leads each to its neighbour along the length of the leads to produce a cable with the leads parallel and side-by-side, except at predetermined regions along the length of the cable where the sheaths are not bonded to each other.

3. A method of manufacturing multi-core cable according to claim 2 which also includes the step of bonding the sheaths, along those portions of the sheaths bonded each to its neighbour, to a backing strip on at least one side of the cable.

4. A method of manufacturing multi-core cable according to claim 3 wherein said backing strip is continuous and so is present at said unbonded regions.

5. A method of manufacturing multi-core cable according to claim 3 wherein the backing strip on at least one side of the cable is bonded in discreet lengths to the sheaths along the portions of the sheaths which are bonded together.

6. A method of manufacturing multi-core cable according to any one of claims 2 to 5 which includes the further step of severing the cable at said regions to produce predetermined lengths of cable having at least one end region wherein the sheaths of the leads are separate from one another.

7. A method of manufacturing multi-core cables according to claim 6 wherein the severing operation is performed in the medial portion of each said region to produce predetermined lengths of cable having both end regions wherein the sheaths of the leads are separate.

8. A method of manufacturing multi-core cable according to any one of claims 2 to 7 wherein the sheaths of the leads are formed from thermoplastic material and the sheaths are fused, each to its neighbour to bond the sheaths together.

9. A method of manufacturing multi-core cable according to claim 1 comprising bonding the insulating sheath of each of a plurality of leads along its length to backing strip on at least one side of the cable except at predetermined regions spaced along the length of the cable, the leads being positioned parallel and side-by-side.

10. A method of manufacturing multi-core cable according to claim 9 wherein the backing strip, or at least one of the backing strips, is continuous.

11. A method of manufacturing multi-core cable according to claim 9 wherein the backing strip, or at least one of the backing strips, is in discreet lengths bonded to the sheaths in spaced relationship to define said regions therebetween.

12. A method of manufacturing multi-core cable according to any one of preceding claims 9 to 11 which includes the further step of severing the cable by cutting through said regions, to produce predetermined lengths of cable having at least one end region wherein the sheaths of the lead are separate from one another and the or each backing strip.

13. A method of manufacturing multi-core cable according to claim 12 wherein the severing operation is performed in the medial portion of said regions to produce predetermined lengths of cable having both end regions wherein the sheaths of the leads are separate from each other and the or each backing strip.

14. A method of manufacturing multi-core cable according to any one of preceding claims 9 to 13 wherein the sheaths of the leads and the backing strip are both formed from thermoplastic material and each sheath is fused to the or each backing strip to bond the lead to the backing strip or strips.

15. A method of manufacturing multi-core cable according to claim 1 wherein opposed continuous insulating strips are bonded together around and between a plurality of conductive cores positioned side-by-side in parallel spaced relationship except at predetermined regions spaced along the length of the cable.

16. A method according to claim 15 wherein the opposed continuous insulating strips are upper and lower insulating strips.

17. A method of manufacturing multi-core cable according to claim 1 wherein opposed insulating strips are bonded together around and between a plurality of conductive cores positioned in parallel, side-by-side spaced relationship wherein at least one of said opposed strips is in the form of a plurality of spaced discreet lengths, the gaps between said lengths defining in the cable regions wherein the cores are separate from one another.

18. A method of manufacturing multi-core cable according to claim 17 wherein the opposed insulating strips are upper and lower insulating strips.

19. A method of manufacturing multi-core cable according to claim 17 or 18 which includes the further step of severing the cable by cutting through said regions.

20. A method of manufacturing multi-core cable according to claim 19 wherein the severing operation is performed in the medial portion of said regions.

21. A method of manufacturing multi-core cable according to any one of claims 17 to 20 wherein said opposed strips are formed from thermoplastic material and are bonded together by fusion.

22. Apparatus for producing multi-core cable by the method according to claim 1, comprising drive means for driving a plurality of leads simultaneously through the apparatus, a bonding station through which the leads pass, the bonding station bonding the insulating sheath of the leads each directly to its neighbour so as to produce a cable wherein the leads extend parallel to one another and side-by-side and interruptor means operable to interrupt the bonding process at predetermined points along the length of the cable being produced so that at said predetermined points in the resultant cable the leads are separate from one another.

23. Apparatus for producing multi-core cable according to any one of preceding claim 22 wherein the apparatus includes on at least one side of the cable means for supplying backing strip from a continuous supply to the bonding station whereby the leads are bonded throughout their length also to said backing strip or strips except in said regions.

24. Apparatus for producing multi-core cable according to claim 22 or claim 23 wherein the apparatus includes on at least one side of the cable means for feeding backing strip from a continuous supply to the bonding station, cutter means in the path of the strip, or of at least one of the strips, to the bonding station for cutting the strip, control means for operating the cutter means to cut the strip into lengths substantially equal in length to the distance between unbonded regions of the sheaths, and pause means associated with the strip feed for spacing the cut ends of consecutive lengths, whereby said bonding station also bonds said lengths of backing strip to the sheaths of the leads throughout the length of the sheaths between said regions wherein the sheaths are separate from one another, there being no backing strip on at least one side of the cable, at said regions.

25. Apparatus for producing multi-core cable according to claim 22 wherein the bonding station includes locating means and means for maintaining tension on the leads past the locating means and co-operating with the locating means to urge the sheaths into close contact during bonding.

26. Apparatus according to claim 25 wherein the locating means is a profile roller.

27. Apparatus according to claim 25 or claim 26 wherein the leads from which the cable is constructed have their insulating sheaths formed from thermoplastics material and the bonding station includes a heater in advance of the locating means, the heater heating the thermoplastic sheaths of the cables to fuse the sheaths each to its neighbour at the locating means and bond the sheaths together.

28. Apparatus for producing multi-core cable according to claim 22 wherein the leads from which the cable is constructed have their insulating sheaths formed from thermoplastic material and the bonding station includes a heater and pressure means, the heater heating the thermoplastic sheaths of the cables and the pressure means pressing the heated sheaths against its neighbour to fuse the sheaths each to its neighbour to bond the sheaths together.

29. Apparatus for producing multi-core cable according to claim 27 or claim 28 wherein the heater is a hot air blower.

30. Apparatus for producing multi-core cable according to any one of claims 27 to 29 wherein said interrupter means is operated to interrupt the heating of the sheaths of the leads.

31. Apparatus for producing multi-core cable according to any one of claims 22 to 30 which includes a guillotine whereby as cable is produced it is severed at said regions to produce predetermined lengths of cable having at least one end region in which the sheaths of the leads are separate from one

another.

32. Apparatus for producing multi-core cable according to claim 31 wherein the guillotine severs the cable at or near the mid-point of said regions so that the predetermined lengths of cable produced have both end regions wherein the sheaths of the leads are separate from one another.

33. Apparatus for producing multi-core cable by the method according to claim 1, comprising drive means for driving a plurality of continuous leads and backing strip, on at least one side of the leads, from a continuous supply through the apparatus, a bonding station wherein the sheaths of the leads are each bonded to the backing strip or strips along their length, with the leads extending side-by-side and parallel to one another to produce a cable, and interruptor means for interrupting the bonding of the sheaths of the leads to the backing strip, or at least one of the backing strips, at predetermined regions along the length of the cable, so that in the resultant cable, in said predetermined regions, the sheaths of the leads are not interconnected.

34. Apparatus for producing multi-core cable according to claim 33 wherein the backing strip on at least one side of the cable extends along the whole length of the cable, said interruptor means interrupting the operation of the bonding station.

35. Apparatus for producing multi-core cable according to claim 33 wherein the interruptor means includes backing strip cutter means in the path of the backing strip, or at least one of the strips, to the bonding station, said cutter means being operable by control means to cut the strip into lengths equal to the distance between said regions and pause means for spacing the cut ends of consecutive strip lengths fed to the bonding station by a distance equal to the discreet length of said regions whereby the bonding station bonds said cut lengths to the leads and the said regions are defined by the distance between the cut ends of consecutive lengths of strip.

36. Apparatus for producing multi-core cable according to any one of preceding claims 33 to 35 wherein the sheaths of the leads and the backing strip or strips are formed from thermoplastic material and the bonding station includes a heater and pressure means, the heater heating at least the mutually presented surfaces of the leads and the backing strip or strips and the pressure means pressing the heated sheaths of the leads against the heated backing strip or strips so that the sheaths fuse to the backing strip to effect the bond therebetween.

37. Apparatus for producing multi-core cable according to claim 36 wherein the heater is a hot air blower.

38. Apparatus for producing multi-core cable according to claim 36 or claim 37 wherein the said interruptor means operates to interrupt the heating of the sheaths of the leads and the backing strip.

39. Apparatus for producing multi-core cable according to any one of claims 33 to 38 wherein the apparatus further includes a guillotine whereby as the cable is produced it is severed at said regions to produce predetermined lengths of cable having at least one end region in which the leads are not interconnected.

40. Apparatus for producing multi-core cable according to claim 39 wherein the guillotine severs the cable at or near the mid-points of said regions so that the lengths of cable produced have both end regions wherein the leads are not interconnected.

41. Apparatus for manufacturing multi-core cable according to claim 1 including drive means for driving through the apparatus a plurality of substantially continuous, conductive cores in side-by-side substantially parallel and spaced relationship, simultaneously with opposed substantially continuous insulating strips, a bonding station wherein the opposed strips are bonded together around and between said cores, and interruptor means for interrupting the bonding of the opposed strips together at predetermined regions along the length of the cable, so that in the resultant cable the cores are insulated and held in position relative to one another throughout their length by the bonding together of said opposed strips except at said regions.

42. Apparatus for manufacturing multi-core cable according to claim 41 wherein the opposed insulating strips are upper and lower strips.

43. Apparatus for manufacturing multi-core cable according to claim 1 including drive means for driving through the apparatus a plurality of substantially continuous conductive cores, in side-by-side substantially parallel and spaced relationship, feed means for feeding opposed insulating strips, a bonding station wherein the opposed strips are bonded together around and between said cores, and interruptor means the operation of which results in the apparatus producing a multi-core cable wherein the cores are insulated and held in position relative to one another throughout their length by the bonding together of said opposed strips except at predetermined regions along the length of the cable, said interruptor means comprising strip cutter means in the path of one or both of the upper and lower strips to the bonding station, control means for controlling operation of the cutter means, to produce cut lengths of said one or other strips equal in length to the distance between said regions and pause means associated with the feed means of said one or both strips for interrupting the feed of one or both strips to produce a gap between the cut ends of consecutive lengths of said one or both strips whereby after bonding together of the opposed strips the gaps between cut ends of consecutive lengths of said one or both strips define said regions wherein the cores are not interconnected.

44. Apparatus for manufacturing multi-core cable according to claim 43 wherein the opposed insulating strips are upper and lower insulating strips.

45. Apparatus for manufacturing multi-core cable according to claim 43 or 44 wherein the opposed strips are formed from thermoplastic material and the bonding station includes a heater and pressure means, the heater heating the mutually presented surfaces of the strips and the pressure means pressing the heated surface of the strips

together around and between the cores so that the strips fuse together to effect the bond therebetween.

46. Apparatus for manufacturing multi-core cable according to claim 45 wherein the heater is a hot air blower.

47. Apparatus for manufacturing multi-core cable according to claim 45 or claim 46 wherein the interruptor means operates to interrupt the heating of the strips.

48. Apparatus for manufacturing multi-core cable according to any one of preceding claims 43 to 47 wherein the apparatus further includes a guillotine whereby as the cable is produced it is severed at said regions to produce predetermined lengths of cable having at least one end region in which the cores are not interconnected by the strips.

49. Apparatus for manufacturing multi-core cable according to claim 48 wherein the guillotine severs the cable at or near the mid-points of said regions so that the lengths of cable produced have both end regions wherein the cores are not interconnected.

50. Multi-core cable manufactured by the method of claim 1 comprising a plurality of leads each including a conductive core in an insulating sheath, the leads extending parallel to one another and side-by-side with the sheath of each lead bonded directly to the sheath of the neighbouring lead along their length, except at regions spaced apart at predetermined intervals along the length of the cable, at which regions the sheaths of the leads are separate from one another whereby predetermined lengths of multi-core cable can be cut from the cable by cutting through said regions so that the cut lengths each have at least one end region wherein the leads are separate from one another.

51. Multi-core cable according to claim 50 wherein the sheaths of the leads of the ribbon cable are formed from a thermoplastics material and are directly bonded together along their length except in said regions by being fused to its neighbour.

52. Multi-core cable according to claim 50 or claim 51 wherein between said regions the sheaths of the leads are also bonded throughout their length to backing strips on at least one side of the cable.

53. Multi-core cable according to claim 52 wherein the backing strip or at least one of the backing strips is omitted in said regions.

54. Multi-core cable according to claim 52 wherein the backing strip or at least one of the backing strips extends throughout the full length of the leads and is bonded to the sheaths of the leads except in said regions.

55. Multi-core cable according to any one of claims 52 to 54 wherein said sheaths are formed from thermoplastic material and said backing strip is also formed from thermoplastic material and in addition to being fused each to its neighbour, each sheath is fused to the backing strip.

56. Multi-core cable manufactured by the method of claim 1 comprising a plurality of leads each including a conductive core in an electrically insulating sheath, the leads extending parallel to one another and side-by-side with the sheath of each of the leads bonded throughout its length to a backing strip on at least one side of the cable except at regions spaced apart at predetermined intervals along the length of the cable, at which regions the sheaths of the leads are separate from the backing strip, whereby predetermined lengths of multi-core cable can be cut from the cable by cutting through said regions so that the cut lengths have at least one end region wherein the leads are separate from one another.

57. Multi-core cable according to claim 56 wherein the backing strip or at least one of the backing strips is continuous.

58. Multi-core cable according to claim 56 wherein the backing strip or at least one of the backing strips is a plurality of discrete lengths each equal in length to the length of leads between said regions.

59. Multi-core cable according to any one of preceding claims 56 to 58 wherein the sheaths of the leads and the backing strip are formed from thermoplastic material and the sheaths of the leads are fused to the or each backing strip to bond the leads to the or each backing strip.

60. Multi-core cable manufactured by the method of claim 1 including a plurality of conductive cores extending parallel to one another in side-by-side spaced relationship, said cores being insulated and held in place relative to each other except at regions spaced apart at predetermined intervals along the cable length, by a common insulating sheath defined by opposed continuous insulating strips bonded together around and between said cores, said strips being separate from one another in said regions, whereby predetermined lengths of multi-core cable can be cut from the cable by cutting through said strips and said cores at said regions so that the cut lengths have at least one end region wherein the cores are not interconnected by said strips.

61. Multi-core cable according to claim 60 wherein the opposed insulating strips are upper and lower insulating strips.

62. Multi-core cable according to claim 60 or claim 61 wherein the opposed strips are formed from thermoplastic material and are fused together except at said regions.

63. Multi-core cable manufactured by the process of claim 1 including a plurality of conductive cores extending parallel to one another in side-by-side spaced relationship, said cores being insulated and held in place relative to each other except at regions spaced apart at predetermined intervals along the cable length, by a common insulating sheath defined by opposed insulating strips bonded together around and between said cores, one or both of said strips being omitted in said regions, whereby predetermined lengths of multi-core cable can be cut from the cable by cutting through the cable at said regions so that the cut lengths have at least one end region wherein the cores are not interconnected by said strips.

64. Multi-core cable according to claim 63 wherein the opposed insulating strips are upper and lower insulating strips.

65. A length of multi-core cable manufactured by the method of claim 1 wherein the end regions of the

leads, at least one end of the length of cable, are separate from one another, having never been interconnected, the sheaths of the leads being bonded directly to each its neighbour throughout the remainder of the length of cable.

66. A length of multi-core cable according to claim 65 wherein both end regions of the length of cable have their leads separate from one another, having never been interconnected.

67. A length of multi-core cable according to claim 65 or claim 66 wherein throughout the portion of the length of cable in which the sheaths are bonded together the sheaths are also bonded to a backing strip on at least one side of the cable.

68. A length of multi-core cable according to any one of claims 65 to 67 wherein the sheaths of the leads are formed from thermoplastic material and each is bonded to its neighbour by being fused thereto.

69. A length of multi-core cable manufactured by the method of claim 1 wherein the end regions of the conductive cores, at least one end of the length of cable, are separate from one another having never been interconnected, the cores being insulated and held in place relative to one another by opposed insulating strips bonded together around and between the cores throughout the remainder of the length of cable.

70. A length of multi-core cable according to claim 69 wherein the opposed insulating strips are upper and lower insulating strips.

71. A length of multi-core cable according to claim 69 or claim 70 wherein both end regions of the length of cable have their cores separate from one another having never been interconnected.

72. A length of multi-core cable according to any one of preceding claims 69 to 71 wherein the opposed strips are formed from thermoplastic material and are bonded together by fusion.

73. Apparatus for producing multi-core cable substantially as described herein with reference to and as illustrated by Figure 1 of the accompanying drawings.

74. Apparatus for producing multi-core cable substantially as described herein with reference to and as illustrated by Figure 2 of the accompanying drawings.

75. Multi-core cable substantially as described herein with reference to and as illustrated by Figures 3 and 4 of the accompanying drawings.

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ABSTRACT:

In multi-core electric cable in which the cores extend in side-by-side spaced and parallel relationship, instead of producing the cable with the cores continuously interconnected by surrounding insulation so that when cut into lengths the insulation has to be pulled or cut apart in order to separate the cores for connecting, the cable is made at the outset with regions 35 at intervals along its length where the cores have never been interconnected. Methods of manufacturing the cable include those in which each core has an individual insulating sheath 34 interconnected to form the multi-core cable by the bonding of the sheaths together or to backing strip material or to both.

In application to multi-core cables made from bare conductors sandwiched between strips of insulating material separation of the cores at intervals is achieved either by omitting at intervals the bonding of the insulating material or by omitting the insulating material at intervals or by a combination of both. Apparatus for, and methods of, so manufacturing flat multi-core electric cable are described. <IMAGE>